

Box 5

THE INFORMATION CONTENT OF INFLATION OPTIONS

Monitoring inflation expectations is crucial for monetary policy. All central banks use a wide range of indicators to collect information, not only on the most likely inflation outcome, but also on the risks surrounding that baseline scenario. This box shows the relevance and limitations of using information from financial options to gauge inflation outcomes. Specifically, it shows that inflation options contain useful, high-frequency information on inflation concerns among market participants. Yet, without specific information on the degree of risk premia and other technical factors, using inflation options to gauge the probability of a certain inflation outcome is problematic. Such probabilities may be better measured via surveys, although these are only available at a lower frequency.

An inflation option can be either a cap or a floor. An inflation cap (floor) is a financial asset that offers protection against inflation being higher (lower) than a given rate of inflation, and can therefore be used by investors to insure against such inflation outcomes. Traded inflation options have a somewhat complex structure. In terms of their design, inflation caps (floors) consist of a series of consecutive caplets (floorlets), each related to the same rate of inflation (the option strike) and with a maturity of one year. An inflation caplet works in a manner similar to that of an equity call option or an interest rate cap:¹ the buyer pays the seller a premium up front (the option price) and, in exchange, the seller pays the buyer the difference between actual inflation in a given period (e.g. one year in the case of a year-on-year option) and a pre-specified rate of inflation (the strike rate) multiplied by the notional amount if the actual inflation rate is higher than the strike rate. In other words, inflation options offer protection against inflation being higher than the strike rate. A floorlet works in the same way if inflation is lower than the strike rate.

In the euro area, inflation caps and floors are traded for several maturities and for several different strikes, normally from -2% to 5%. Unfortunately, although it has grown significantly in recent years, liquidity in this market remains limited and trades are often concentrated on a few strikes. Nonetheless, subject to the crucial assumption of risk-neutrality,² one can use options prices to extract so-called risk-neutral probability densities for future inflation outcomes.³ It is important to note, however, that option-implied risk-neutral probability densities are not equivalent to the actual probabilities of inflation perceived by market players, because they incorporate a risk premia component, as market participants are in reality risk averse. In this context, it should be borne in mind that a change in option-implied probabilities may reflect not only a change in actual probabilities of inflation perceived by investors, but also a change in the risk premia. Risk aversion is likely to have been particularly high since the beginning of the financial crisis and, in particular, the premia paid for some of the lowest and highest rates of inflation have probably been elevated. Some recent research on US and UK inflation options suggests that this has been the case in both of these markets.⁴

Chart A shows the time series of risk-neutral probability density functions implied by five-year (year-on-year) inflation options, which, according to market intelligence, are the most liquid maturity. Specifically, it depicts the option-implied mean inflation rate (as the solid line) and the option-implied variability in the form of different percentiles for implied inflation outcomes. It follows that the option-implied variability (the “width” of the percentiles) has increased and become more volatile since the beginning of the financial crisis. This may reflect increased uncertainty about inflation or increased risk premia. However, since August 2012 the option-implied variability has been on a declining path.

To exemplify the possible role of risk aversion, Chart B compares the cumulative option-implied probability mass assigned to deflation with the same probability mass obtained from the ECB’s

1 Analogously, an inflation floor is similar to an equity put option or an interest rate floor.

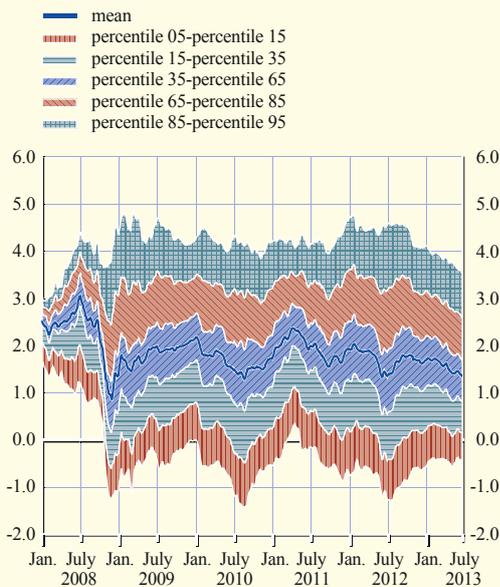
2 Risk neutrality is a standard assumption used in financial analysis for derivative pricing.

3 For a description of the methodology employed here, see de Vincent-Humphreys, R. and Puigvert Gutiérrez, J.M., “A quantitative mirror on the EURIBOR market using implied probability density functions,” *Working Paper Series*, No 1281, ECB, December 2010. For a description of different methods for deriving implied densities, see also Andersen, A.B. and Wagener, T., “Extracting risk neutral probability densities by fitting implied volatility smiles: some methodological points and an application to the 3M EURIBOR futures option prices”, *Working Paper Series*, No 198, ECB, December 2002.

4 See Kitsul, Y. and Wright, J.H., “The economics of options-implied inflation density functions”, *NBER Working Paper Series*, No 18195, updated version, National Bureau of Economic Research, 2013; and Smith, T., “Option-implied probability distributions for future inflation”, *Quarterly Bulletin*, Q3, Bank of England, 2012.

Chart A Risk-neutral inflation probability densities implied by five-year inflation cap and floor prices

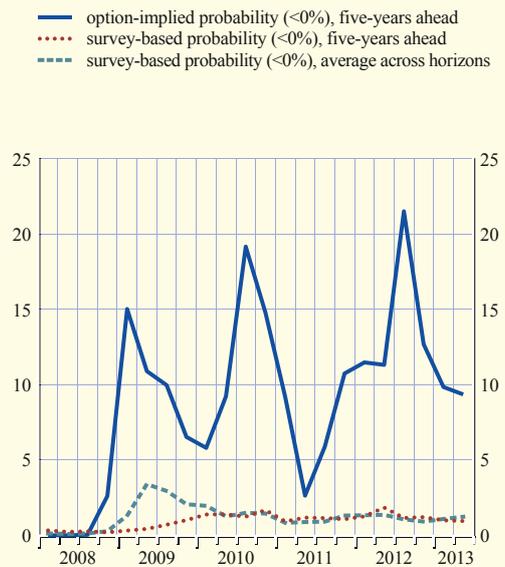
(implied quantiles in percentages per annum; January 2008 – June 2013; daily data; five-day moving averages)



Sources: Royal Bank of Scotland and ECB calculations.

Chart B Option-implied and survey-based probability of deflation

(percentages; quarterly data; Q1 2008 – Q2 2013)



Source: ECB calculations.

Survey of Professional Forecasters (SPF).⁵ Every quarter, the SPF asks respondents to assign probability to the event of inflation falling within some pre-specified intervals, i.e. for a density forecast in the form of a histogram. Averaged across respondents, one obtains a probability density that may be seen as representing the actual probability density perceived by economic agents (irrespective of the degree of inflation risk aversion).

It follows that the option-implied probability of deflation is higher than the SPF-based probability. For instance, the option-implied probability of deflation was volatile and averaged 9% over the sample as a whole, while the SPF-probability of deflation was stable and only averaged 1%. Overall, the correlation between deflation probabilities based on the two measures is below 0.5 over the sample as a whole. Averaging the deflation probabilities over short horizons (one year and two years ahead) and the longer horizon (five years ahead), or considering short horizon expectations in isolation to control for the potential influence of inflation risks over such horizons, does not help to reconcile the deflation probabilities derived from the two measures. Option-implied densities also assign significantly higher probability to high inflation (i.e. higher than 4%) than survey forecasts. Overall, this confirms that the option-implied probabilities for extreme inflation outcomes are substantially biased by risk premia.

Moreover, in addition to the assumption of risk-neutrality, some technical assumptions on the shape of the density are needed to estimate the option-implied probabilities, which have an

5 For a non-technical description of the ECB's SPF, see Garcia, J.A., "An introduction to the ECB's Survey of Professional Forecasters", *Occasional Paper Series*, No 8, ECB, September 2003. For a detailed report of the most recent survey round, see the box entitled "Results of the Survey of Professional Forecasters for the second quarter of 2013", *Monthly Bulletin*, ECB, May 2013.

impact on the quantitative results. Such assumptions are needed because the inflation options market, although growing rapidly, is marked by limited liquidity and is still in a somewhat premature state of development. In the same vein, the fact that trades are concentrated on the extreme inflation outcomes complicates the estimation of option-implied probabilities for moderate inflation outcomes.

Irrespective of these technical challenges and the fact that it is normally not possible to interpret option-implied probabilities as characterising the actual probability distribution of inflation, option-implied probabilities still offer relevant, high-frequency information on the joint effect of inflation risk aversion and actual inflation probabilities. For instance, if the risk-neutral probability of a certain extreme inflation outcome decreases, this generally suggests reduced fears of that inflation outcome in the market, either because the actual probability of the outcome has declined in the view of the market or because the market has become less risk averse. Moreover, the information content of inflation options is very likely to continue to grow in the future as the inflation option market deepens.